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(54) **COMPLIANT PIN FOR RETAINING AND ELECTRICALLY CONNECTING A SHIELD WITH A CONNECTOR ASSEMBLY**

(75) Inventors: **Matthew Sypolt**, Harrisburg, PA (US); **James Lee Fedder**, Etters, PA (US)

(73) Assignee: **Tyco Electronics Corporation**, Berwyn, PA (US)

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(51) **Int. Cl.**
H01R 13/648 (2006.01)

(52) **U.S. Cl.** **439/607.07**

(58) **Field of Classification Search** 439/751, 439/82, 607.05–607.07
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,183,067 A * 12/1939 Gardner 439/825
3,696,323 A * 10/1972 Kinkaid et al. 439/525
3,997,237 A * 12/1976 White 439/876
4,186,982 A * 2/1980 Cobaugh et al. 439/82
4,655,537 A * 4/1987 Andrews, Jr. 439/751
4,737,114 A * 4/1988 Yaegashi 439/82
4,906,209 A * 3/1990 Tanabe et al. 439/620.24
5,055,072 A * 10/1991 Shinoda 439/751
6,524,129 B2 * 2/2003 Cote et al. 439/511
6,743,057 B2 * 6/2004 Davis et al. 439/701
6,932,649 B1 * 8/2005 Rothermel et al. 439/620.01
7,074,094 B2 7/2006 Kawahara et al.
7,172,461 B2 * 2/2007 Davis et al. 439/607.11
7,175,446 B2 * 2/2007 Bright et al. 439/79
7,357,673 B2 4/2008 Long
7,410,393 B1 * 8/2008 Rothermel et al. 439/607.05
7,585,186 B2 * 9/2009 McAlonis et al. 439/607.05
7,618,289 B2 * 11/2009 Rothermel et al. 439/607.07

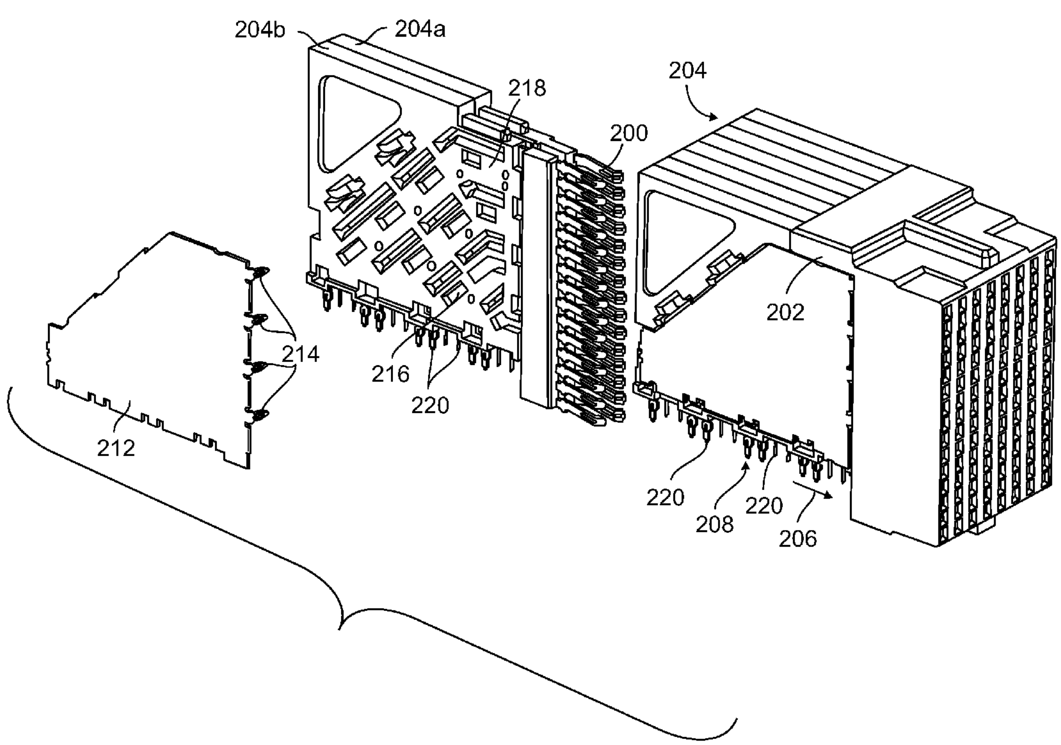
* cited by examiner

Primary Examiner—Neil Abrams

(57) **ABSTRACT**

A compliant pin is configured to be press-fit into a cavity of at least one of a connector assembly and a substrate to retain the pin in the cavity. The pin includes a neck, a plurality of compliant beams, and an insertion tip. The neck interconnects the pin with the connector assembly. The beams are configured to engage an inner surface of the cavity to retain the pin in the cavity. The beams are arranged side-to-side and project along a longitudinal plane in a loading direction. The beams have arcuate portions that are arched in different directions transverse to the longitudinal plane. The arcuate portions are shaped to deflect toward the longitudinal plane without substantially engaging one another. The insertion tip interconnects the ends of the beams.

20 Claims, 8 Drawing Sheets



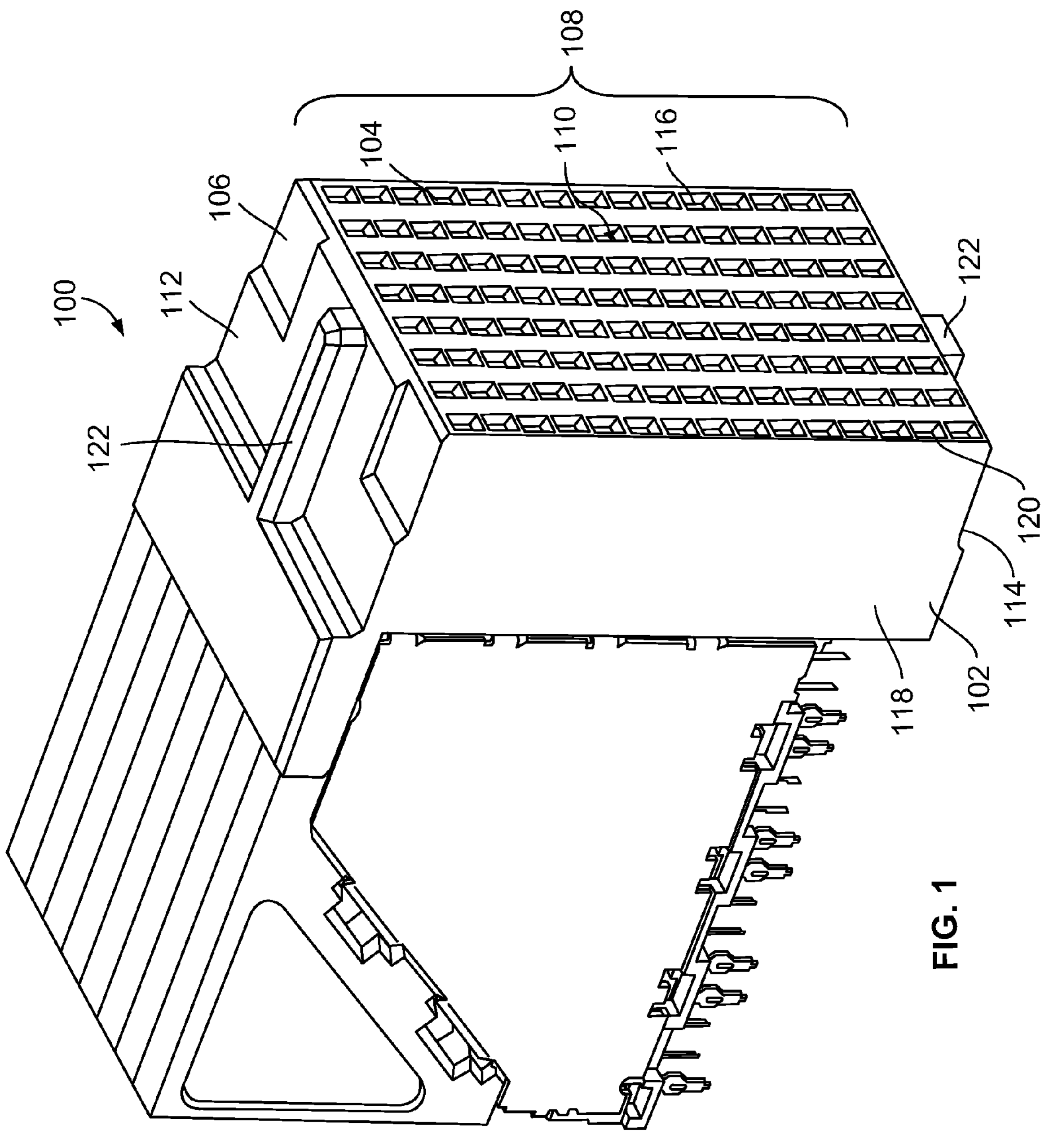


FIG. 1

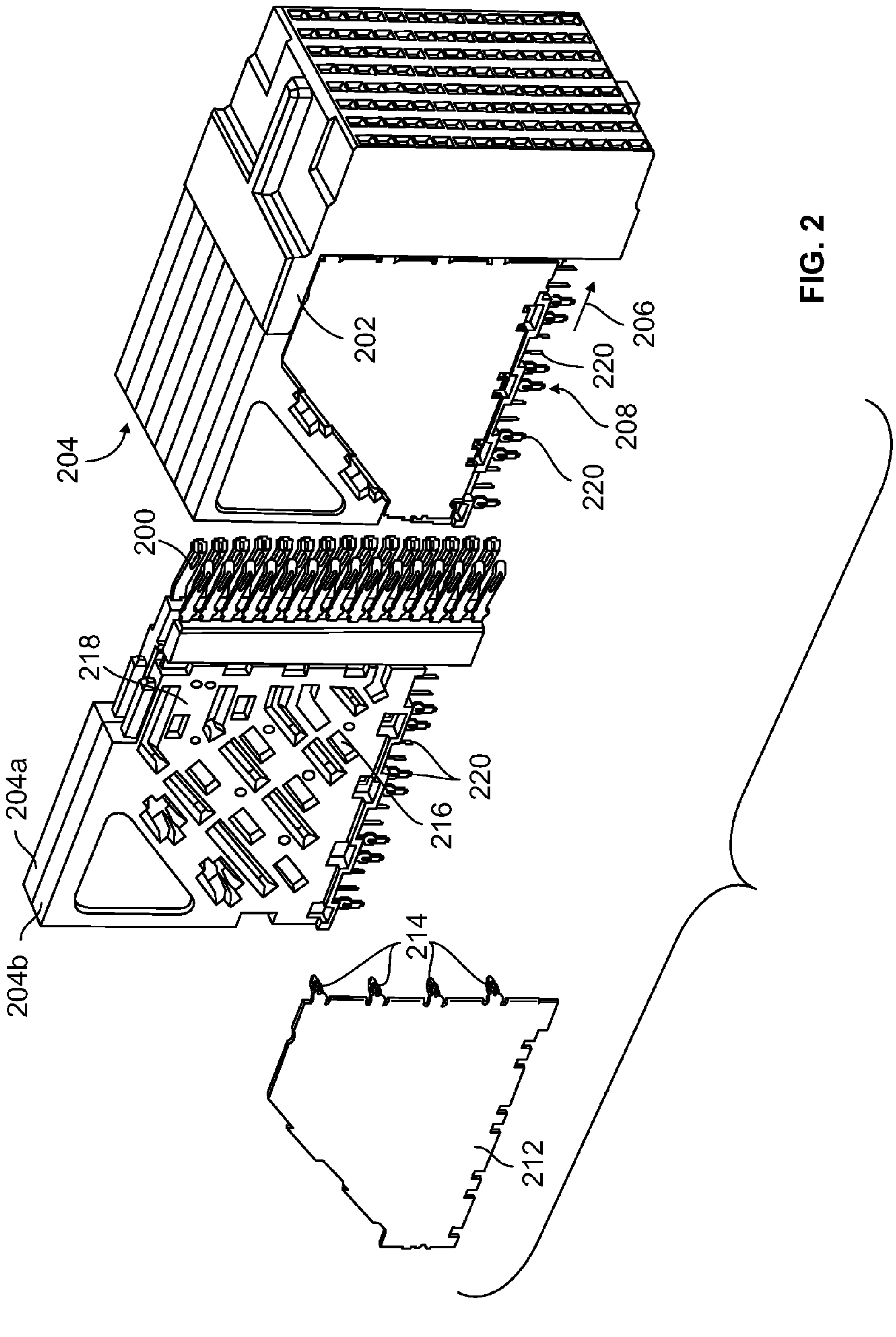


FIG. 2

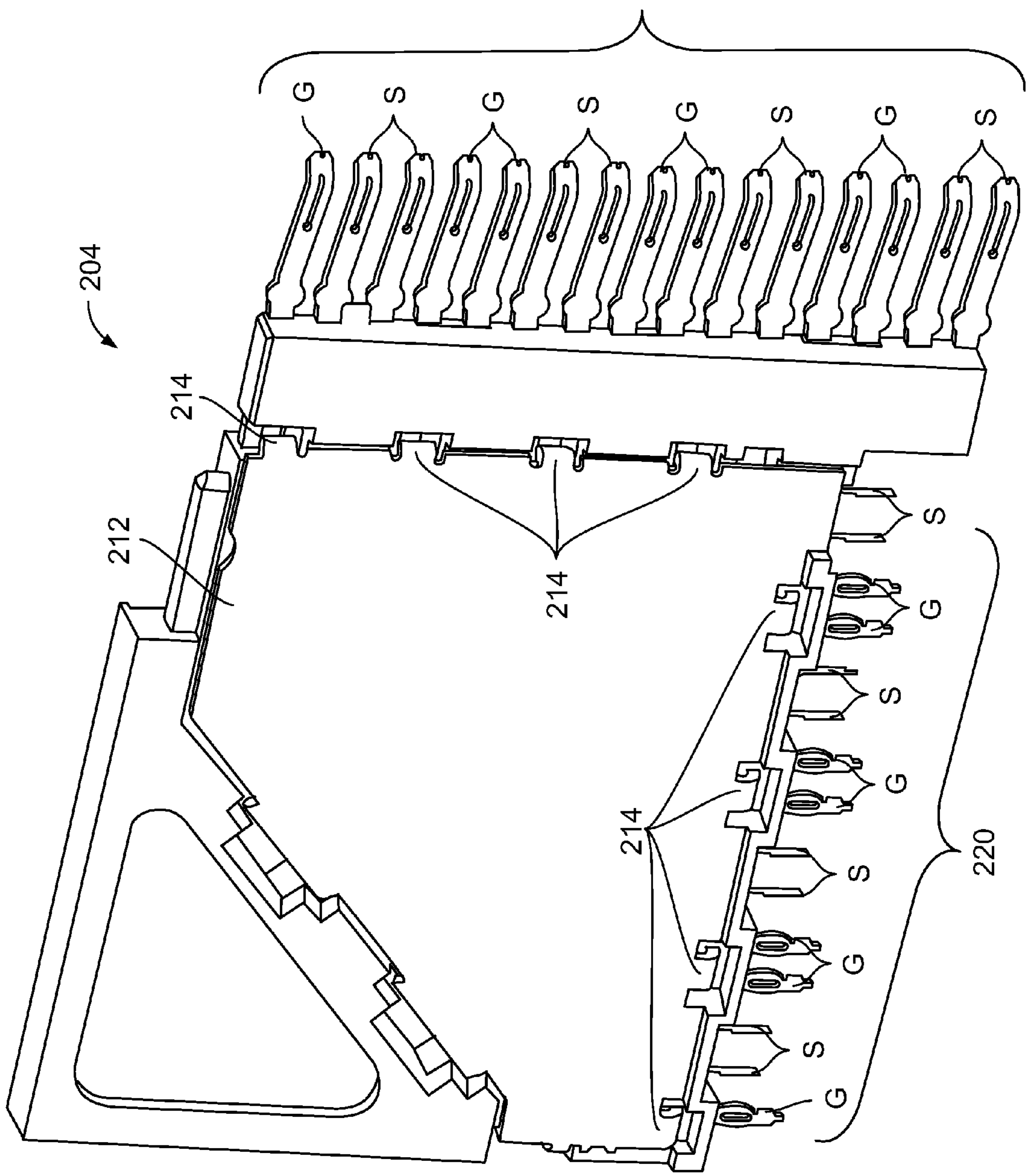
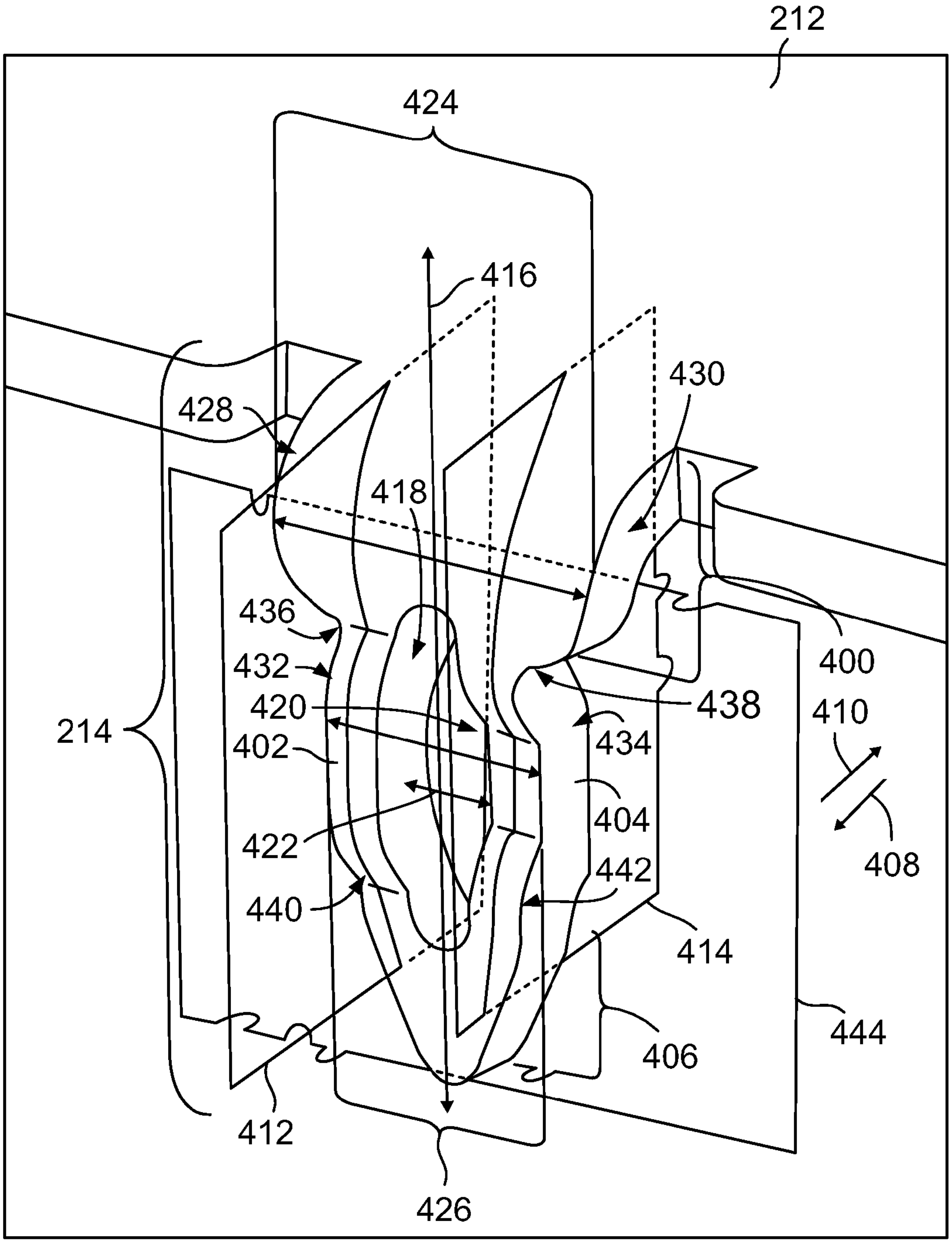


FIG. 3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424
416
430
428
418
436
432
420
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214
438
410
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404
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442
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414
406
444
412
426
400
408

FIG. 4

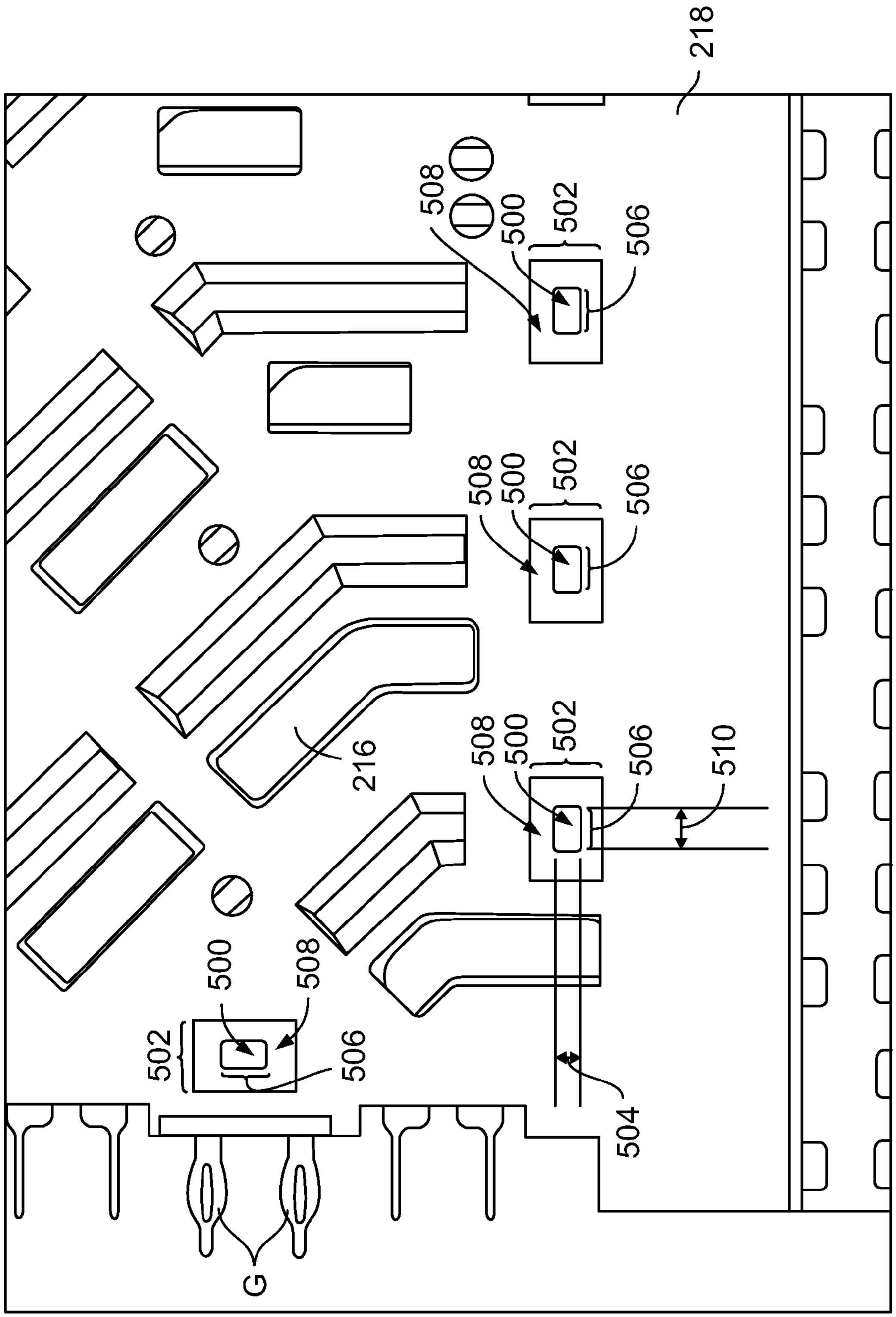

FIG. 5

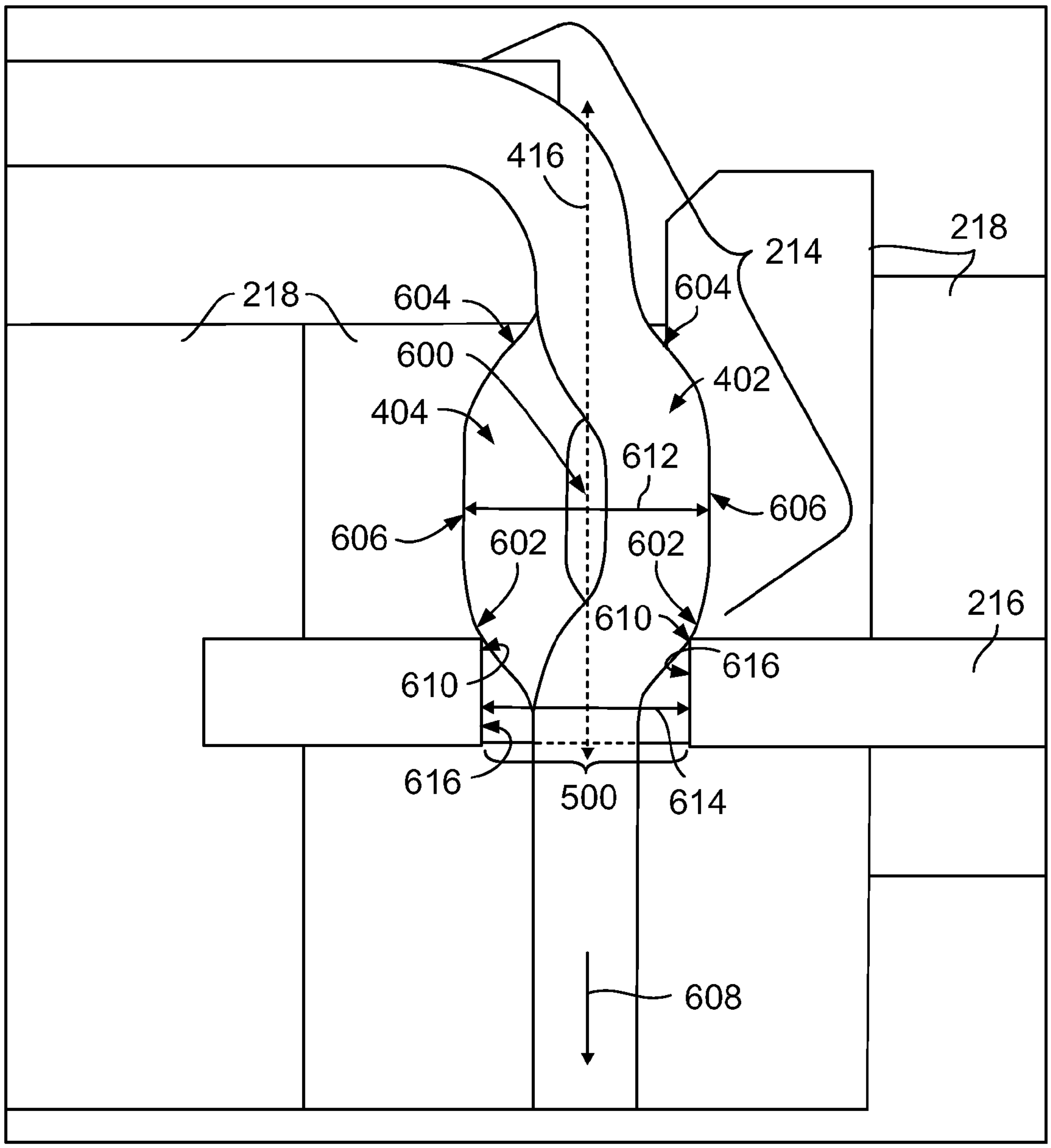
416
214
218
218
604
604
600
402
404
612
606
606
602
602
610
216
610
616
616
500
614
608

FIG. 6

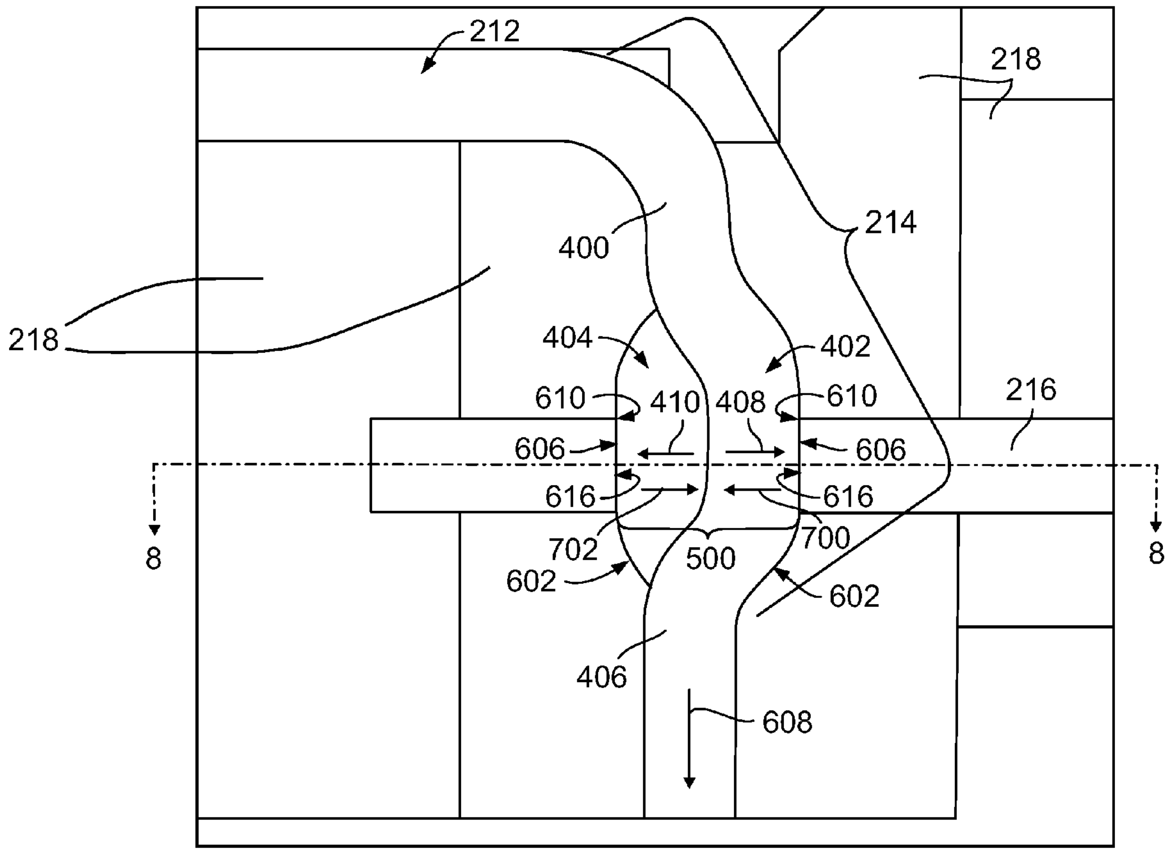
212
218
214
400
218
404
402
610
410
408
610
216
606
606
616
616
702
700
8
500
8
602
602
406
608

FIG. 7

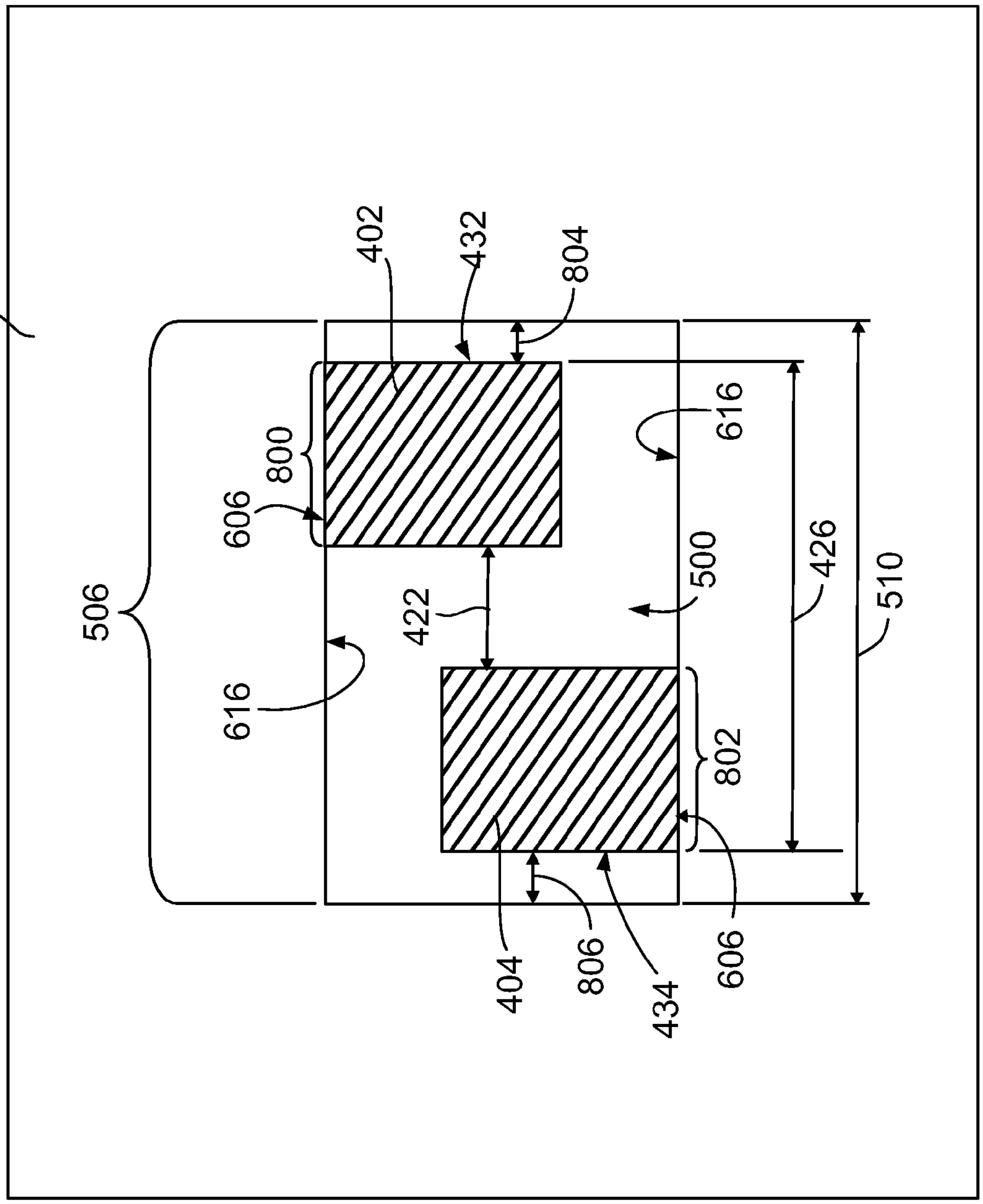
216
402
432
804
616
800
606
506
500
422
426
510
616
802
404
806
434
606

FIG. 8

COMPLIANT PIN FOR RETAINING AND ELECTRICALLY CONNECTING A SHIELD WITH A CONNECTOR ASSEMBLY

BACKGROUND OF THE INVENTION

The subject matter herein generally relates to electrical connectors and, more particularly, to compliant pins for electrical connectors.

Known Eye-Of-Needle ("EON") pins are used to mechanically and electrically connect shields in connector assemblies with at least one of another component of the connector assembly and a substrate. For example, known EON pins are used to electrically connect shields with the electric ground of a circuit board and/or a conductor that is electrically connected to the electric ground of the circuit board. The EON pins are press-fit into cavities in the circuit board and/or another component in the connector assembly. The EON pins include an approximately oval shaped opening enclosed by outwardly bent beams of the EON pins. The EON pins are press-fit into cavities by applying an insertion force on the EON pins in a loading direction directed into the cavities. Application of the insertion force on the EON pins in the loading direction forces the EON pins into the cavities. As the EON pins are forced into the cavities, the beams are bent toward each other. The beams engage the inner surface of the cavity to electrically and mechanically couple the pin with the circuit board and/or component in the connector assembly.

These EON pins are relatively large when compared to the size and dimensions of other known signal pins used in the same connector assemblies. Moreover, these EON pins require relatively large insertion forces when compared to the structural integrity of the EON pins. For example, the insertion forces required to press-fit the EON pins into the cavities frequently cause the EON pins to buckle if the EON pins are not perfectly aligned with the cavities.

BRIEF DESCRIPTION OF THE INVENTION

In one embodiment, a compliant pin is configured to be press-fit into a cavity of at least one of a connector assembly and a substrate to retain the pin in the cavity. The pin includes a neck, a plurality of compliant beams, and an insertion tip. The neck interconnects the pin with the connector assembly. The beams are configured to engage an inner surface of the cavity to retain the pin in the cavity. The beams are arranged side-to-side and project along a longitudinal plane in a loading direction. The beams have arcuate portions that are arched in different directions transverse to the longitudinal plane. The arcuate portions are shaped to deflect toward the longitudinal plane without substantially engaging one another. The insertion tip interconnects the ends of the beams.

In another embodiment, a connector assembly includes a contact module assembly and a shield. The contact module assembly includes a lead frame that has a cavity and is configured to electrically connect the connector assembly with an electric ground. The shield has a compliant pin press-fit into the cavity to retain the shield with respect to the lead frame and to electrically connect the shield with the electric ground. The pin includes a neck, a plurality of compliant beams and an insertion tip. The neck interconnects the pin with the shield. The beams are configured to engage an inner surface of the cavity to retain the pin in the cavity. The beams are arranged side-to-side and project along a longitudinal plane in a loading direction. The beams have arcuate portions that are arched in different directions transverse to the longitudinal plane. The arcuate portions arc shaped to deflect toward the longitudinal plane without substantially engaging one another. The insertion tip interconnects the ends of the beams.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an electrical connector assembly according to one embodiment.

FIG. **2** is an exploded view of the connector assembly shown in FIG. **1**.

FIG. **3** is an assembled view of a contact module assembly shown in FIG. **2** with an example shield also shown in FIG. **2** affixed thereto.

FIG. **4** is a perspective view of a compliant pin shown in FIG. **2** prior to the pin being press-fit into a lead frame shown in FIG. **2** according to one embodiment.

FIG. **5** illustrates a portion of the lead frame shown in FIG. **2** and a dielectric body also shown in FIG. **2**.

FIG. **6** is a side elevational view of the pin shown in FIG. **2** prior to loading the pin into a cavity shown in FIG. **5**.

FIG. **7** is a side elevational view of the pin shown in FIG. **2** after being loaded into the cavity shown in FIG. **5**.

FIG. **8** is a partial cross sectional view of a plurality of beams shown in FIG. **4** after the pin shown in FIG. **2** is press-fit into the cavity shown in FIG. **5** taken along line **8-8** in FIG. **7**.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** is a perspective view of an electrical connector assembly **100** according to one embodiment. While the connector assembly **100** is described herein with particular reference to a backplane receptacle connector, it is to be understood that the benefits herein described are also applicable to other connectors in alternative embodiments. The following description is therefore provided for purposes of illustration, rather than limitation, and is but one potential application of the subject matter herein. The connector assembly **100** includes a dielectric housing **102** having a forward mating end **104** that includes a shroud **106** having a mating interface **108** at the mating end **104**. A plurality of mating contacts **200** (shown in FIG. **2**), such as, for example, contacts within contact cavities **110**, are provided proximate to the mating interface **108** and are configured to receive corresponding mating contacts (not shown) from a mating connector (not shown). The shroud **106** includes an upper surface **112** and a lower surface **114** between opposed sides **116**, **118**. The upper and lower surfaces **112**, **114** and sides **116**, **118** each include a chamfered forward edge portion **120**. An alignment rib **122** is formed on the upper surface **112** and lower surface **114**. The forward edge portion **120** and the alignment ribs **122** cooperate to bring the connector assembly **100** into alignment with the mating connector during the mating process so that the contacts in the mating connector are received in the contact cavities **110** without damage.

FIG. **2** is an exploded view of the connector assembly **100**. As shown in FIG. **2**, the housing **102** also includes a rearwardly extending hood **202**. A plurality of contact module assemblies **204** are received in the housing **102** from a rearward end **206**. The contact module assemblies **204** define a connector mounting interface **208**. The connector mounting interface **208** includes a plurality of mounting contacts **220**, such as, but not limited to, pin contacts, that are configured to be mounted to a substrate (not shown), such as, but not limited to, a circuit board. The mounting contacts **220** include ground and signal contacts. In one embodiment, the mounting interface **208** is substantially perpendicular to the mating interface **108** such that the electrical connector assembly **100** interconnects electrical components that are substantially at a right angle to one another. The housing **102** may hold two or more different types of contact module assemblies **204**, such as, but not limited to, contact module assemblies **204**A, **204**B. Alternatively, the housing **102** may hold only a single type of contact module assembly **204**, such as, but not limited to, any of the contact module assemblies **204**A, **204**B.

In an example embodiment, each of the contact module assemblies **204** includes a lead frame **216** that is partially housed in a dielectric body **218**. As illustrated in FIG. **2**, the lead frame **216** is enclosed within the body **218**, but is at least partially exposed by the body **218** in certain areas. In one or more embodiments, the body **218** is manufactured using an over-molding process. During the molding process, the lead frame **216** is encased in a dielectric material, which forms the body **218**. The mating contacts **200** and mounting contacts **220** extend from the body **218** and the lead frame **216**. The contact module assemblies **204** include a shield **212** that extends along one side thereof. Optionally, the shield **212** may define a ground plane for the respective contact module assembly **204**. In the illustrated embodiment, the shield **212** includes a plurality of compliant pins **214** that electrically and mechanically connects to the lead frame **216**. Optionally, the shield **212** may be used to provide shielding between adjacent contact module assemblies **204**.

FIG. **3** is an assembled view of the contact module assembly **204**A (shown in FIG. **2**), with an example shield **212** affixed thereto. While FIG. **3** illustrates the contact module assembly **204**A, the contact module assembly **204**B (shown in FIG. **2**) also may include a similar shield **212**. The mating contacts **200** of the contact module assembly **204**A include a plurality of conductors, including both ground and signal conductors (identified in FIG. **3** with a G for ground conductors or an S for signal conductors). The ground and signal conductors G, S extend at least partially into the contact module assembly **204**A. During assembly, the shield **212** is mounted to the contact module assembly **204**A. The compliant pins **214** of the shield **212** are electrically and mechanically connected to the ground conductors G of the mating and mounting contacts **200**, **220**. In one or more embodiments, the shield **212** is electrically connected to less than all of the ground conductors G. When installed, the shield **212** defines a ground plane that is oriented parallel to, but in a non-coplanar relation with, the lead frame plane. In one embodiment, when the shield **212** is installed, the shield **212** at least partially covers each of the ground and signal conductors G, S of the lead frame **100**. The shield **212** also is electrically connected with one or more of the ground conductors G. The ground conductors G are electrically connected to an electrical ground of the substrate (not shown) to which the connector assembly **100** (shown in FIG. **1**) is mounted and/or an electrical ground of the mating connector (not shown) that mates with the connector assembly **100**. As a result, the shield **212** may effectively shield the signal conductors S from an adjacent contact module assembly **204**B (shown in FIG. **2**) when the contact module assemblies **204**A, **204**B are assembled within the housing **102**.

FIG. **4** is a perspective view of the compliant pin **214** prior to the pin **214** being press-fit into the lead frame **216** shown in FIG. **2** according to one embodiment. The compliant pin **214** and shield **212** include, or are formed from, a conductive material such as a metal material. For example, the compliant pin **214** and shield **212** may be homogeneously formed with one another from a common piece of conductive metal. In one embodiment, the pin **214** and the shield **212** are stamped and formed from a common sheet of metal. The pin **214** and shield **212** may be coated with a conductive material, such as a conductive plating.

The pin **214** is coupled with the shield **212** of the connector assembly **100** (shown in FIG. **1**) by a neck **400**. In the illustrated embodiment, the neck **400** is bent so that a longitudinal axis **416** of the pin **214** is approximately perpendicular to the shield **212**. Alternatively, the neck **400** may be bent so that the longitudinal axis **416** is not perpendicular to the shield **212**. For example, the longitudinal axis **416** may be parallel to the shield **212**.

A plurality of beams **402**, **404** is coupled to the neck **400** and interconnects the neck **400** with an insertion tip **406**. The beams **402**, **404** project from upper ends **436**, **438** to lower ends **440**, **442** along a longitudinal plane **444** of the pin **214**. The upper ends **436**, **438** are interconnected by the neck **400** and the lower ends **440**, **442** are interconnected by the insertion tip **406**. The longitudinal axis **416** of the pin **214** is disposed in the longitudinal plane **444**. In the illustrated embodiment, the longitudinal plane **444** is transverse to the shield **212**. For example, the longitudinal plane **444** is not parallel to the shield **212** in FIG. **4**. In one embodiment, the longitudinal plane **444** is transverse to the shield **212** by being disposed at an acute angle with respect to the shield **212**. In another embodiment, the longitudinal plane **444** is transverse to the shield **212** by being disposed approximately perpendicular to the shield **212**. Alternatively, the pin **214** may be coupled to the shield **212** such that the longitudinal plane **444** is not transverse to the shield **212**. For example, the longitudinal plane **444** may be parallel to the shield **212**.

The beams **402**, **404** are bent so that the beams **402**, **404** outwardly protrude from the longitudinal plane **444** of the pin **214** in opposing directions. For example, the beams **402**, **404** include arcuate shapes that are arched in different directions **408**, **410** from the longitudinal plane **444** in the illustrated embodiment. The arcuate shape of the beams **402**, **404** may include a shape that is an approximately smooth arch and a shape that includes one or more approximately flat edges or surfaces such as contact surfaces **606** (shown in FIG. **6**) of the beams **402**, **404**. As shown in FIG. **4**, the left beam **402** is arched in one direction **408** and the right beam **404** is arched in a different direction **410**. In one embodiment, the directions **408**, **410** oppose one another. For example, the directions **408**, **410** may extend parallel to one another. Alternatively, the directions **408**, **410** may be skew with respect to one another. For example, the directions **408**, **410** may be disposed at an angle with respect to one another. The terms "left" and "right" are used merely as examples and are not intended to be limiting in any way. For example, the left beam **402** may be arched toward the direction **410** and the right beam **404** may be arched toward the other direction **408**. The beams **402**, **404** are disposed side-to-side so the beams **402**, **404** are arched away from the longitudinal plane **444** in different beam planes **412**, **414**. The beam planes **412**, **414** are parallel to one another and are transverse to the longitudinal plane **444** in the illustrated embodiment. For example, the beam planes **412**, **414** may be disposed at one or more acute angles with respect to the longitudinal plane **444** or may be disposed approximately perpendicular to the longitudinal plane **444**. In the illustrated embodiment, beams **402**, **404** are separated from one another by a separation gap **422** that extends approximately perpendicular to the beam planes **412**, **414** and along the longitudinal plane **444** such that the beams **402**, **404** are not arched away from one another in a single plane.

The neck **400** has a neck width **424** along the longitudinal plane **444** that is greater than a beams width **426** of the beams **402**, **404** that extends along the longitudinal plane **444** in the illustrated embodiment. For example, the neck width **424** between opposing neck sides **428**, **430** of the neck **400** in the longitudinal plane **444** is larger than the beams width **426** between outer surfaces **432**, **434** of the beams **402**, **404** in the longitudinal plane **444**. Providing the neck **400** with a greater neck width **424** than the beams width **426** of the beams **402**, **404** can increase the strength of the pin **214** so as to reduce the possibility of the pin **214** buckling when the pin **214** is press-fit into a cavity **500** (shown in FIG. **5**).

An inner surface **418** of the pin **214** defines an opening **420** between the beams **402**, **404**. For example, the inner surface **418** may define the approximately oval-shaped opening **420** in the longitudinal plane **444** shown in FIG. **4**. The opening **420** may have a different shape in another embodiment and/or in a different plane. The opening **420** extends in the longitudinal plane **444** between the neck **400** and the insertion tip **406** and separates the beams **402**, **404** from one another. The separation gap **422** defines the width of the opening **420** in the longitudinal plane **444**.

The insertion tip **406** includes a pointed shape that is pointed along the longitudinal axis **416** of the pin **214**. The pointed shape of the insertion tip **406** can reduce the force required to load the pin **214** into a cavity **500** (shown in FIG. **5**) in the lead frame **216** (shown in FIG. **2**). The insertion tip **406** projects away from the neck **400** along the longitudinal plane **444** in the illustrated embodiment.

FIG. **5** illustrates a portion of the lead frame **216** and the dielectric body **218** shown in FIG. **2** according to one embodiment. The lead frame **216** extends in a plane that is transverse to the pin **214** (shown in FIG. **2**) in one embodiment. For example, a top surface **508** of the lead frame **216** may be disposed approximately perpendicular to, or at an acute angle with respect to, the longitudinal plane **444** (shown in FIG. **4**) of the pin **214**. The lead frame **216** includes a plurality of cavities **500** that are each shaped to receive the pins **214**. The pins **214** are press-fit into the cavities **500** to mechanically secure and retain the shield **212** (shown in FIG. **2**) with respect to the lead frame **216**. The dielectric body **218** includes a plurality of access openings **502** located over the cavities **500**. The access openings **502** are positioned to permit the pins **214** to be loaded into the cavities **500** so that the dielectric body **218** is located between the shield **212** and the lead frame **216** when the connector assembly **100** (shown in FIG. **1**) is assembled. As described below, the pins **214** are press-fit into the cavities **500** to mechanically and electrically couple the shield **212** with the lead frame **216**. The cavities **500** may be formed in the lead frame **216** such that an inner surface **616** (shown in FIG. **6**) of the cavities **500** is electrically connected with the lead frame **216** and one or more ground conductors G. For example, the lead frame **216** may include, or be formed from a conductive material with the cavities **500** exposing an inner conductive portion of the lead frame **216**. Alternatively, the inner surface **616** (shown in FIG. **6**) of each cavity **500** may include, or be at least partially coated with, a conductive material. Mounting the shield **212** to the lead frame **216** using the pins **214** can electrically connect the shield **212** to an electric ground of the lead frame **216**.

The cavities **500** define a polygon-shaped opening **506** in the top surface **508** of the lead frame **216** in one embodiment. For example, each of the cavities **500** in FIG. **5** defines a rectangular shaped opening **506** in the lead frame **216**. Alternatively, the cavities **500** may define a different shaped opening **506** or a polygon-shaped opening **506** that is a polygon shape other than a rectangle. The openings **506** have a width **510** that is greater than a height **504** in the illustrated embodiment. For example, the width **510** of the openings **506** may be approximately 0.6 millimeters and the height **504** may be approximately 0.4 millimeters. In one embodiment, the width **510** and height **504** of the openings **506** are smaller than the dimensions of openings (not shown) in known lead frames (not shown) that receive pins (not shown) to electrically and mechanically connect a shield (not shown) with the lead frame. Reducing the size of the openings **506** can reduce the pitch of the pins **214** (shown in FIG. **2**) that are press-fit into the cavities **500**. For example, reducing the size of the openings **506** can allow for the cavities **500** and the pins **214** to be provided closer together than in known connector assemblies. Reducing the size of the openings **506** also can reduce the amount of conductive material that surrounds each opening **506**. For example, reducing the dimensions of the openings **506** can reduce the amount of conductive material that is coated on the lead frame **216** around and/or in the cavities **500**.

FIG. **6** is a side elevational view of the pin **214** prior to loading the pin **214** into the cavity **500** according to one embodiment. The lead frame **216** and dielectric body **218** are shown in cross-sectional view in FIG. **6**. Additionally, the pin **214** in FIG. **6** is presented as though viewed from a direction that is transverse to the beam planes **412**, **414** (shown in FIG. **4**) and is along the longitudinal plane **444** (shown in FIG. **4**). The longitudinal plane **444** may be represented by the longitudinal axis **416** as shown in FIG. **6**. The pin **214** is loaded into the cavity **500** in a loading direction **608**. The loading direction **608** is approximately parallel to the longitudinal axis **416** and along the longitudinal plane **444** of the pin **214** in one embodiment.

As described above, the beams **402**, **404** are arched in opposing directions **408**, **410** (shown in FIG. **4**). In the illustrated embodiment, the beams **402**, **404** are arched so as to define an opening **600** between the beams **402**, **404** when the beams **402**, **404** are viewed from a direction that is transverse to the longitudinal axis **416** and along the longitudinal plane **444** (shown in FIG. **4**) of the pin **214**. For example, the opening **600** is defined in a plane that is approximately parallel to the beam planes **412**, **414** (shown in FIG. **4**) and transverse to the longitudinal plane **444**. Each of the beams **402**, **404** includes lower and upper angled surfaces **602**, **604** with a contact surface **606** between the lower and upper angled surfaces **602**, **604**. In the illustrated embodiment, the contact surfaces **606** are approximately parallel to one another. As the pin **214** is loaded into the cavity **500** in the loading direction **608**, the lower angled surface **602** of each beam **402**, **404** first engages an upper edge **610** of the cavity **500**. The upper edge **610** of the cavity **500** is the edge of the opening **506** (shown in FIG. **5**) defined by the cavity **500**. A depth **612** of the beams **402**, **404** is the distance between the contact surfaces **606** of the beams **402**, **404** in a direction that is transverse to the longitudinal plane **444** (shown in FIG. **4**). The depth **612** of the beams **402**, **404** is greater than an inner dimension **614** of the cavity **500**. The inner dimension **614** is the distance between opposing sides of an inner surface **616** of the cavity **500** in a direction that is parallel to the direction in which the depth **612** is measured.

FIG. **7** is a side elevational view of the pin **214** after being loaded into the cavity **500** according to one embodiment. In a manner similar to FIG. **6**, FIG. **7** presents the lead frame **216** and dielectric body **218** in cross-sectional view and the pin **214** as though viewed from a direction that is transverse to the beam planes **412**, **414** and is along the longitudinal plane **444** as shown in FIG. **4**. The lower angled surfaces **602** of the beams **402**, **404** slide along the upper edge **610** of the cavity **500** as the pin **214** is press-fit into the cavity **500** along the loading direction **608**. The beams **402**, **404** are deflected in deflection directions **700**, **702** as the pin **214** is press-fit into the cavity **500**. For example, as described above and shown in FIG. **4**, the left beam **402** is arched along the direction **408** and the right beam **404** is arched along the different direction **410**. Pressing the pin **214** into the cavity **500** causes the beams **402**, **404** to be at least partially deflected toward the longitudinal plane **444** (shown in FIG. **4**) in deflection directions **700**, **702**. For example, the beams **402**, **404** may be partially flattened toward the longitudinal plane **444**. In one embodiment, the deflection directions **700**, **702** are different from one another. For example, the deflection directions **700**, **702** may oppose one another. In another example, the deflection directions **700**, **702** are disposed at an acute angle with respect to one another. In the illustrated embodiment, the deflection direction **700** of the beam **402** is substantially opposite to the direction **408** in which the beam **402** is arched in the beam plane **412** (shown in FIG. **4**) and the deflection direction **702** of the beam **404** is substantially opposite to the direction **410** in which the beam **404** is arched in the beam plane **414** (shown in FIG. **4**).

Once the pin **214** is press-fit into the cavity **500**, the contact surfaces **606** of the beams **402**, **404** engage one or more of the inner surface **616** and the upper edge **610** of the cavity **500** to retain the pin **214** in the cavity **500**, and thus secure the shield **212** in position with respect to the lead frame **216**. The contact surfaces **606** engage one or more of the inner surface **616** and the upper edge **610** to electrically connect the pin **214** and the lead frame **216**.

With additional reference to FIG. **4**, the beams **402**, **404** are separated from one another by the separation gap **422** prior to, during and after the pin **214** is press-fit into the cavity **500** in one embodiment. The beams **402**, **404** are separated from one another so that the beams **402**, **404** do not substantially engage one another as the beams **402**, **404** are deflected along the deflection directions **700**, **702**. For example, the portions of the inner surface **418** of the pin **214** that are located proximate to the beams **402**, **404** are separated from one another such that the beams **402**, **404** do not rub against, slide against or otherwise engage one another when the pin **214** is press-fit into the cavity **500** such that the beams **402**, **404** do not frictionally engage one another. In one embodiment, the greatest separation gap **422** in the longitudinal plane **444** between the beams **402**, **404** is approximately the same before and after the pin **214** is press-fit into the cavity **500**. For example, the initial width of the opening **420** may not substantially change after the pin **214** is press-fit into the cavity **500**. In another example, the opening **420** separates the beams **402**, **404** and extends between the neck **400** and the insertion tip **406** before and after the pin **214** is press-fit into the cavity **500** and the beams **402**, **404** are biased in the directions **700**, **702**.

The beams **402**, **404** do not substantially engage one another to avoid significantly increasing the amount of loading force that is applied to the pin **214** in the loading direction **608** to press-fit the pin **214** into the cavity **500**. For example, the beams **402**, **404** do not substantially engage one another when the pin **214** is press-fit into the cavity **500** to avoid requiring a loading force that would cause the pin **214** to buckle if the pin **214** is misaligned with respect to the cavity **500**. In another example, the loading force that is applied to the pin **214** in the loading direction **608** to press-fit the pin **214** in the cavity **500** is reduced over known compliant pins. Reducing the amount of loading force that is required to press-fit the pin **214** into the cavity **500** can reduce the chances of the pin **214** buckling. For example, as the amount of insertion force that is required to press-fit a known pin (not shown) into a known cavity (not shown) increases, the pin is more likely to buckle. Conversely, as the amount of insertion force that is required to press-fit the pin **214** is reduced over known pins, the pin **214** is less likely to buckle when loaded into the cavity **500**.

Keeping the beams **402**, **404** separated as the pin **214** is press-fit into the cavity **500** can prevent parts of the beams **402**, **404** from shearing or peeling off of the pin **214**. For example, a conductive plating on the pin **214** may be prevented from being skived from the beams **402**, **404** by separating the beams **402**, **404** from one another during loading of the pin **214** into the cavity **500**. In doing so, at least some of the conductive plating on the beams **402**, **404** is protected from being removed, thus exposing the underlying base material of the pin **214**, in one embodiment.

In the illustrated embodiment, the beams **402**, **404** are deflected toward the deflection directions **700**, **702** as the pin **214** is loaded into the cavity **500** sufficiently far so that the opening **600** (shown in FIG. **6**) is closed in a plane that is approximately parallel to the beam planes **412**, **414** and transverse to the longitudinal plane **444**. For example, the opening **600** that is visible from a direction that is transverse to the beam planes **412**, **414** (shown in FIG. **4**) prior to press-fitting the pin **214** into the cavity **500** may no longer be visible from this same direction after the pin **214** is loaded into the cavity **500**. The opening **600** may no longer be visible due to the biasing of the beams **402**, **404** toward directions **700**, **702** sufficiently far to eliminate or close the opening **600** when viewed from the direction transverse to the beam planes **412**, **414**.

FIG. **8** is a partial cross-sectional view of the beams **402**, **404** after the pin **214** (shown in FIG. **2**) is press-fit into the cavity **500** taken along line **8-8** in FIG. **7**. Only cross-sections of the beams **402**, **404** are shown in FIG. **8** with the rest of the pin **214** removed from the view of FIG. **8**. As described above, the beams **402**, **404** are separated by the separation gap **422** prior to and after the pin **214** is press-fit into the cavity **500** in one embodiment. The beams **402**, **404** have a polygon-shaped cross-sectional shape in a plane that is parallel to the top surface **508** (shown in FIG. **5**) of the lead frame **216**. For example, the beams **402**, **404** may have a square- or rectangular-shaped cross-section. The cross-sectional shape of the beams **402**, **404** can increase the retention of the pin **214** in the cavity **500**. For example, the cross-sectional shape of the beams **402**, **404** can increase the surface area of the interface between the beams **402**, **404** and the lead frame **216**. Increasing the surface area of the interface between the beams **402**, **404** and the lead frame **216** can increase the amount of force required to remove the pin **214** from the cavity **500**.

For example, the interface between the pin **214** (shown in FIG. **2**) and the lead frame **216** includes a plurality of interface areas **800**, **802** between the contact surfaces **606** of the beams **402**, **404** and at least one of the inner surface **616** and the upper edge **610** of the cavity **500**. While only the inner surface **616** is labeled in FIG. **8**, the upper edge **610** also may be labeled using the same arrow as is used to label the location of the inner surface **616**. The interface areas **800**, **802** include the surface area in which the contact surfaces **606** engage the inner surface **616** within the cavity **500** and/or the upper edge **610** of the cavity **500**. The engagement between the substantially flat contact surfaces **606** and one or more of the inner surface **616** and upper edge **610** increases the surface area of the interface areas **800**, **802** between the pin **214** and the lead frame **216** when compared to known pins (not shown) and cavities (not shown) of a similar size and of a different shape. Increasing this surface area causes the force required to remove the pin **214** from the cavity **500** to be increased.

In one embodiment, the width **510** of the opening **506** defined by the cavity **500** is greater than the beam width **426** of the beams **402**, **404**. For example, the opening **506** of the cavity **500** may be sufficiently large such that one or more side gaps **804**, **806** are provided between outside surfaces **432**, **434** of the beams **402**, **404** and opposing sides of the inner surface **616** of the cavity **500**. The outside surfaces **432**, **434** of the beams **402**. **404** include the outermost surfaces of the beams **402**, **404** in a plane that is perpendicular to the beam planes **412**, **414** in one embodiment. For example, the beans width **426** of the beams **402**, **404** may be defined as the distance between the outside surfaces **432**, **434** of the beams **402**, **404** in a direction that is perpendicular to the one or more of the beam planes **412**, **414** and the longitudinal axis **416** (shown in FIG. **4**) of the pin **214**. The opening **506** may be sufficiently large to provide the side gaps **804**, **806** when the pin **214** is press-fit into the cavity **500** to provide additional tolerance for the loading of the pin **214** into the cavity **500**. For example, inclusion of the side gaps **804**, **806** can provide additional tolerance for the location of the pin **214** in the cavity **500** so that the pin **214** does not need to be perfectly centered in the opening **506**.

It is to be understood that the above description is intended to be illustrative, and not restrictive. For example, the above-described embodiments (and/or aspects thereof) may be used in combination with each other. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from its scope. Dimensions, types of materials, orientations of the various components, and the number and positions of the various components described herein are intended to define parameters of certain embodiments, and are by no means limiting and merely are example embodiments. Many other embodiments and modifications within the spirit and scope of the claims will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. In the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Moreover, in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects. Further, the limitations of the following claims are not written in means—plus-function format and are not intended to be interpreted based on 35 U.S.C. §112, sixth paragraph, unless and until such claim limitations expressly use the phrase "means for" followed by a statement of function void of further structure.

What is claimed is:

1. A connector assembly comprising:

a contact module assembly comprising a lead frame having a cavity and configured to electrically connect the connector assembly with an electric ground; and

a shield having a compliant pin press-fit into the cavity to retain the shield with respect to the lead frame and to electrically connect the shield with the electric ground, the pin comprising:

a neck interconnecting the pin with the shield;

a plurality of compliant beams configured to engage an inner surface of the cavity to retain the pin in the cavity, the beams arranged side-to-side and projecting along a longitudinal plane in a loading direction, the beams having arcuate portions arched in different directions transverse to the longitudinal plane, the arcuate portions being shaped to deflect toward the longitudinal plane without substantially engaging one another; and

an insertion tip interconnecting ends of the beams.

2. The connector assembly of claim **1**, wherein the beams of the pin are deflected along non-intersecting deflection paths when the pin is press-fit into the cavity.

3. The connector assembly of claim **1**, wherein the beams comprise substantially flat contact surfaces that engage the inner surface of the cavity to electrically connect the pin and the inner surface of the cavity, the contact surfaces being substantially parallel to one another.

4. The connector assembly of claim **1**, wherein the beams are separated from one another to avoid frictionally engaging one another when the pin is press-fit into the cavity.

5. The connector assembly of claim **1**, wherein a separation distance between the beams along the longitudinal plane is approximately constant prior to and after the pin is press-fit into the cavity.

6. The connector assembly of claim **1**, wherein the neck of the pin has an exterior width along the longitudinal plane that is greater than an exterior width of the plurality of beams along the longitudinal plane.

7. The connector assembly of claim **1**, wherein the pin defines an opening between the beams in a plane transverse to the longitudinal plane prior to the pin being press-fit into the cavity.

8. The connector assembly of claim **7**, wherein the beams are deflected toward the longitudinal plane to close the opening in the transverse plane when the pin is press-fit into the cavity.

9. The connector assembly of claim **1**, wherein the cavity defines a polygon-shaped opening in a plane that is transverse to the longitudinal plane of the pin, the beams comprising substantially flat surfaces that engage opposing sides of the polygon-shaped opening.

10. The connector assembly of claim **1**, wherein the cavity extends along a cavity width that is wider in a plane transverse to the longitudinal plane of the pin than an exterior width of the beams after the pin is press-fit into the cavity.

11. A connector assembly comprising:

a housing;

contact module assemblies disposed in the housing, the contact module assemblies including conductive lead frames located in dielectric bodies and including cavities disposed on at least one side of the dielectric bodies, the lead frames including mounting contacts configured to be mounted to a circuit board; and

a conductive shield coupled with at least one of the contact module assemblies, the shield including compliant pins received in the cavities of the at least one of the lead frames to electrically couple the shield with the lead frames and the mounting contacts, the compliant pins including compliant beams that engage inner surfaces of the cavities, the beams arranged side-to-side and projecting along a longitudinal plane in a loading direction, the beams having arcuate portions arched in different directions that are transverse to the longitudinal plane, the arcuate portions being shaped to deflect toward the longitudinal plane without substantially engaging one another when the pins are loaded into the cavities.

12. The connector assembly of claim **11**, wherein the pins of the conductive shield include insertion tips that interconnect ends of the beams of the pins.

13. The connector assembly of claim **11**, wherein the arcuate portions of the pins are arched in opposing directions.

14. The connector assembly of claim **11**, wherein the beams of the pins are deflected along non-intersecting deflection paths when the pins are press-fit into the cavities.

15. The connector assembly of claim **11**, wherein the beams of the pins comprise substantially flat contact surfaces that engage the inner surfaces of the cavities to electrically connect the pins and the inner surfaces of the cavities, the contact surfaces of each pin being substantially parallel to one another.

16. The connector assembly of claim **11**, wherein the beams of the pins are separated from one another to avoid frictionally engaging one another when the pins are loaded into the cavities.

17. The connector assembly of claim **11**, wherein a separation distance between the beams of each of the pins along the longitudinal plane is approximately constant prior to and after the pins are press-fit into the cavities.

18. The connector assembly of claim **11**, wherein the pins of the shield include necks that interconnect the beams with the shield, the necks having exterior widths along the longitudinal plane that are greater than exterior widths of the beams along the longitudinal plane.

19. The connector assembly of claim **11**, wherein the cavities of the contact module assemblies define polygon-shaped openings in a plane that is transverse to the longitudinal plane, the beams comprising substantially flat surfaces that engage opposing sides of the polygon-shaped openings.

20. The connector assembly of claim **11**, wherein the pins of the shield define openings between the beams in planes that are transverse to the longitudinal plane prior to the pins being press-fit into the cavities, the beams being deflected toward the longitudinal plane to close the openings in the transverse plane when the pins are press-fit into the cavities.

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